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Editorial

Soil Management for Sustainable Agriculture

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The soil sustains most living organisms, being the ultimate source of their mineral nutrients. Good management of soils ensures that mineral elements do not become deficient or toxic to plants, and that appropriate mineral elements enter the food chain. Soil management is important, both directly and indirectly, to crop productivity, environmental sustainability, and human health. Because of the projected increase in world population and the consequent necessity for the intensification of food production, the management of soils will become increasingly important in the coming years. To achieve future food security, the management of soils in a sustainable manner will be the challenge, through proper nutrient management and appropriate soil conservation practices. Research will be required to avoid further degradation of soils, through erosion or contamination, and to produce sufficient safe and nutritious food for healthy diets.

The aim of this special issue is to present current research to assure food security whilst preserving natural resources. It comprises 16 papers arising from the Soil Management for Sustainable Agro-Food Systems Session at the European Geosciences Union General Assembly in April 2011. These range from reviews of the effects of different soil management practices on the sustainability of agricultural systems to papers reporting the influence of specific organic and inorganic amendments on the productivity and quality of particular crops.

The Special issue begins with an overview by P. J. White et al. of the role of plant mineral nutrition in food production, the delivery of essential mineral elements to the human diet, and the prevention of harmful mineral elements entering the food chain. The authors describe our progress towards global food security through the development of improved agronomic practices and novel crop genotypes for the sustainable intensification of agriculture. This paper is complemented by articles by R. Saha et al., who review the consequences of deforestation coupled with shifting cultivation practices on soil degradation in Northeast India, and S. E. Obalum et al., who review the problem of soil degradation in Sub-Saharan Africa. R. Saha et al. report massive losses of soil, soil carbon (C), nitrogen (N), phosphorus (P), potassium (K), calcium, magnesium, manganese, and zinc (Zn) following deforestation in the northeastern hill region of India with shifting cultivation practices. The consequent reduction in soil fertility prevents sustained agricultural production. However, they note that the adoption of appropriate agroforestry systems can reduce soil losses, increase soil organic matter (SOM), improve soil physical properties, and preserve water resources. In addition, techniques such as zero or minimum tillage, mulching, cultivating cover crops, and hedgerow intercropping can be used to increase SOM and sustain soil health. S. E. Obalum et al. report that land degradation, particularly soil erosion, also has a significant negative effect on soil quality and productivity in Sub-Saharan Africa. These authors propose the adoption of a lowland-based rice-production technology, termed the sawah ecotechnology, to meet demands for food security in this region. They argue that this farmer-oriented, low-cost system of managing soil, water, and nutrient resources could not only improve agricultural productivity but also alleviate the negative environmental impacts of land degradation in this region.

In many areas of the world, the loss of topsoil, either through mineral imbalance or erosion, is the single largest threat to agricultural productivity. Soil erosions by wind and water are the main processes by which topsoil is lost. R. García-Moreno et al. report that soils with high soil surface roughness (SSR), such as those produced with conservation tillage, are less susceptible to erosion, and that there is an inverse relationship between SSR and soil porosity. They suggest that these soil properties might be used to predict the susceptibility of a soil to erosion by wind or water.

The influence of tillage on the physical, chemical, and microbiological properties of the soil is considered in several papers in this Special issue, with reference to specific agricultural systems. X. Gao and C. A. Grant report that durum wheat (*Triticum durum*) grown in the Canadian prairies tends to have greater grain yield, greater grain Zn concentrations, and lower grain cadmium (Cd) concentrations when cultivated with reduced tillage than with conventional tillage. The preceding crops in the rotation, whether spring wheat-flax, or canola-flax have little influence on grain yield, grain Cd concentration, or Zn concentration, but increasing P-fertilizer application tends to decrease grain Zn concentrations. This study suggests that tillage management can have beneficial effects on both grain yield and nutritional quality. R. P. Mathew et al. compared the long-term effects of conventional tillage and no-tillage practices on soil microbial communities in a silt loam soil under continuous maize (*Zea mays*) production in Alabama, USA. They observed that microbial biomass was greater in the topsoil from the untilled plots than the conventionally tilled plots, and also had greater phosphatase activity and higher carbon and nitrogen contents. The authors conclude that conservation tillage practices can, therefore, improve both the microbiological and physicochemical properties of soil. A. Munodawafa reports that grain yields of maize grown under semiarid conditions on the infertile, sandy soils of southern Zimbabwe can be predicted accurately from the amount and timing of rainfall. She observes that, for a given amount of rainfall, similar yields were achieved using mulch ripping ($0.13\,t\,ha^{-1}\,cm^{-1}$ rainfall) and conventional tillage ($0.12\,t\,ha^{-1}\,cm^{-1}$ rainfall), which were greater than those using tied ridging ($0.09\,t\,ha^{-1}\,cm^{-1}$ rainfall). However, much greater soil erosion occurred using conventional tillage than mulch ripping or tied ridging cultivation. She recommends that mulch ripping be practiced in this region, since the loss of topsoil under conventional tillage will ultimately result in a decline in productivity over time. M. Watkins et al. observe that in the well-managed dairy pastures of the Gippsland Region of south-eastern Australia, P and N are lost to the environment as dissolved rather than particulated forms. They report that the concentrations of P and N in soil solutions from ryegrass (*Lolium perenne*) or mixed ryegrass and clover (*Trifolium repens*) pastures are significantly lower in ploughed than in unploughed plots. Thus, they conclude that ploughing might reduce the amounts of P and N released to the environment from intensive dairy farms in this region.

Organic amendments often improve the productivity of soils and the nutritional value of crops grown thereon. In particular, crop residues can be used to increase the phytoavailability of essential mineral nutrients, reduce the phytoavailability of toxic mineral elements, improve soil physical properties, and promote a beneficial soil biota. In Ghana, cassava is an important staple crop, but it is also be used as a raw material for the production of industrial starch and ethanol. S. Adjei-Nsiah and O. Sakyi-Dawson demonstrate that cassava can contribute to mineral nutrient recycling, and to the maintenance of soil fertility, when integrated into crop rotations. Furthermore, they argue that the production of cassava for industrial purposes can contribute to poverty reduction without excessive depletion of soil mineral resources in the forest/savannah agroecological zone of Ghana. S. Adjei-Nsiah also reports that palm bunch ash, one of the major waste products generated from processing palm fruit, can be used as an effective, local, low-cost, K-fertilizer and liming material for maize production in Ghana. C. A. Abreu et al. report that the application of sugar cane filter cake at 40–80 $Mg\,ha^{-1}$ organic-C can reduce barium (Ba) concentrations and increase shoot dry matter of sunflower (*Helianthus annuus*) and castor oil (*Ricinus communis*) plants, but not oilseed radish (*Raphanus sativus*), growing on a Brazilian soil (pH 7.5) contaminated with automobile scrap. However, neither sugar cane filter nor peat applications reduced soil Ba availability, which, they suggest, might be due to an effect of liming the soil. K. L. Rothlisberger et al. demonstrate that seed meal remaining after the extraction of oil for biodiesel production from white mustard (*Sinapis alba*), Indian mustard (*Brassica juncea*), camelina (*Camelina sativa*), or jatropha (*Jatropha curcas*) can act as a bioherbicide on johnsongrass (*Sorghum halepense*) and redroot pigweed (*Amaranthus retroflexus*), but that the efficacy and specificity of their bioherbicidal effects are related to plant species and affected by rate and timing of their application. M. M. Moreno et al. compared SOM, SOM mineralization, microbial biomass, and microbial activity in organic and conventional production systems for a rainfed crop rotation (durum wheat-fallow-barley-vetch) in the semiarid region of Castilla-La Mancha, Spain. Although it is often observed that management practices supplying more carbon to the system lead to the accumulation of more SOM, greater soil microbial biomass, and increased microbial activity, they observed that SOM was higher with chemical fertilization, which, they speculate, might be a consequence of either low compost inputs ($2500\,kg\,ha^{-1}$) to the organic rotation or the arid conditions. Soil nitrate content was also higher when chemical fertilizers were applied, as were crop yields.

A. Korsaeth reports the N, P, and K budgets over a ten-year period of six crop rotations in a long-term experiment in southeast Norway. He observes that the conventional arable system and the three organic systems studied had negative N budgets, suggesting a reduction in soil N content. By contrast, a modified arable-farming practice with environmentally sound management appeared to be balanced with respect to N, and conventional practice for mixed dairy production generated an N surplus. Budgets for all conventional systems indicated P and K surpluses, whereas all organic systems appeared to mine the soil for P and K. Although these calculations corresponded well with the measured changes in topsoil P, only a common ranking of the systems for their N and K budgets and the measured N and K in topsoil was observed. He concludes, therefore, that crop production could be mining a soil of N and K over many years before it is detected by traditional soil analyses, and that nutrient budgeting might be used to predict mineral imbalances of agricultural practices. In a similar study, P. Sharma et al. compared irrigation efficiencies, and water and nitrate balances, for onions (*Allium cepa*) grown with furrow or drip irrigation in an arid area of southern New Mexico where water is a limited resource for crop production. They observed that both the irrigation efficiency and the N-fertilizer use efficiency were slightly greater for drip systems than for furrow systems.

The paper of this special issue by J. A. Campos et al. reports the concentrations of 18 mineral elements in fruiting bodies from ectomycorrhizal, saprophytic, and epiphytic fungi from a mixed forest of pines and oaks on quartzite acidic soils in Ciudad Real, Spain. They report significantly higher copper (Cu) and rubidium (Rb) concentrations in fruiting bodies from ectomycorrhizal species and significantly higher Zn concentrations in fruiting bodies from saprophytic species. The species *Clitocybe maxima* and *Suillus bellini* appear to "hyperaccumulate" Cu and Rb, respectively.

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